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ABSTRACT

This report reviews the most current data on women's progress in mathematics and science achievement, attitudes, course-taking patterns, and college majors. Results of recent studies suggest that many factors such as parental encouragement, teacher preparation, teacher student interactions, curriculum content, hands-on laboratory experiences, self-concept, attitudes toward mathematics and science, availability of mentors, and home resources contribute to the attitudes, access, and achievement of young women in mathematics and science. The research cited here suggests that the gender gap in science and mathematics in the United States appears at Grade 10 while internationally the gap appears around Grade 8. Despite this, there are still substantial differences between women and men in mathematics, computer science, engineering and science fields. Contains 29 references. (DDR)

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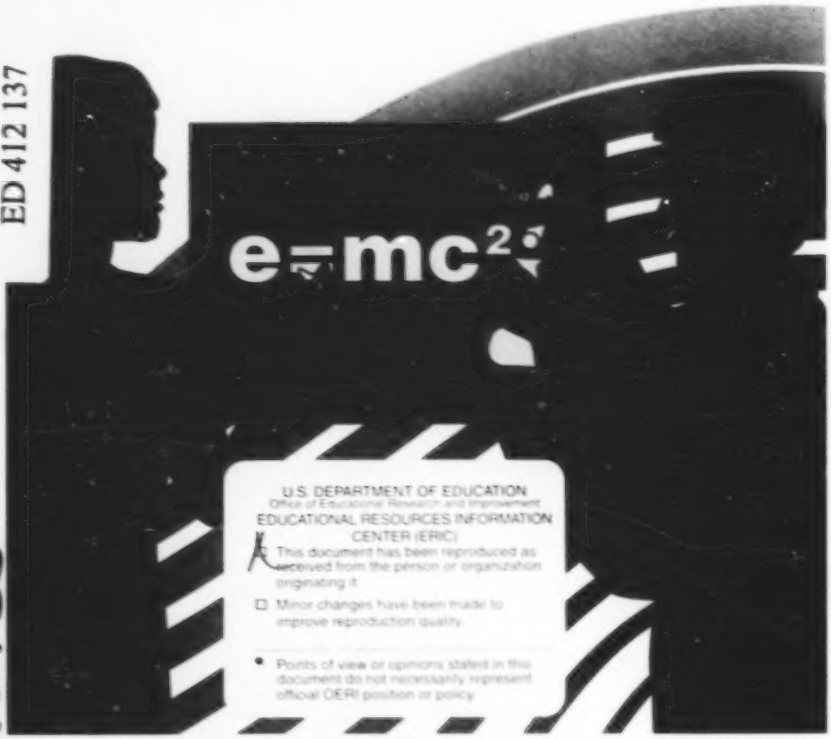
Findings from

THE CONDITION OF EDUCATION 1997

NO. 11

WOMEN IN MATHEMATICS AND SCIENCE

ED 412 137



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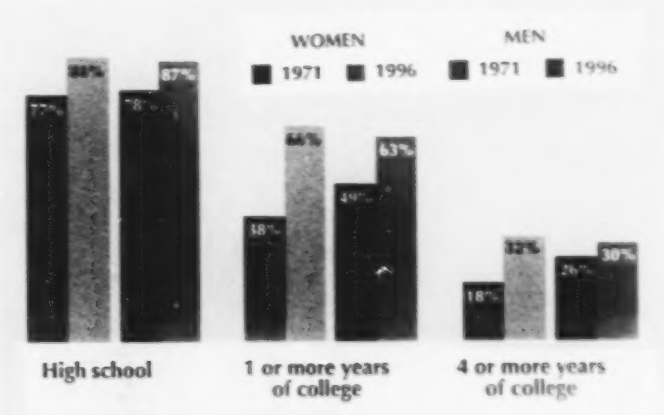
The text in this booklet was written by Yupin Bae of Pinkerton Computer Consultants, Inc. and Thomas M. Smith of NCES and appears in ***The Condition of Education, 1997****. Rebecca Pratt, Ginger Rittenhouse, Andrea Livingston, Karyn Madden, and Barbara Kridl edited the text, and Leslie Retallick, Mary Sukkestad, and Don Eike designed the graphics and layout.*

WOMEN IN MATHEMATICS AND SCIENCE

In the past two decades, women have made tremendous progress in education, putting them on par with men in many respects. The large gaps in the education levels between women and men that were evident in the early 1970s have essentially disappeared for the younger generation. For example, in 1995, women were as likely as men to attend college immediately following high school graduation,[1] and in 1996, young women aged 25–29 were more likely to have completed at least some college than young men of the same age. Young women were also just as likely as young men to have completed at least a bachelor's degree.

Percentage of 25- to 29-year-olds who have completed selected levels of education, by sex: March 1971 and 1996



SOURCE: U.S. Department of Commerce, Bureau of the Census, March Current Population Surveys.

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These trends indicate that women have made important strides toward closing the educational gap between men and women. It is also important, however, to examine how women have progressed in specific areas that are important to domestic and international competitiveness. Goal Five of the National Education Goals states that "by the year 2000, U.S. students will be first in the world in mathematics and science achievement."[2] Specifically, the objectives of this goal emphasize that the number of women studying mathematics, science, and engineering should increase significantly. Including achievement in mathematics and science as one of the National Education Goals exemplifies how important these fields are to the United States and to our global competitiveness. Therefore, closing the gender gap in overall educational attainment is not considered enough; significant progress must also be made in the crucial fields of mathematics and science.

Research studies suggest that many factors contribute to the attitudes, access, and achievement of young women in mathematics and science: encouragement from parents, preparation of mathematics and science teachers, interactions between teachers and students, curriculum content, hands-on laboratory experiences, self-concept, attitudes toward mathematics, high school achievement in mathematics and science, availability of mentors, and resources available at home.[3] This essay reviews the most current data on women's progress in mathematics and science achievement, attitudes, course-taking patterns, and college majors. The final section summarizes earnings differences between women and men who majored in mathematics and science in college.

Mathematics and Science Achievement of Male and Female Students

Proficiency in mathematics and science is an important outcome of education. In an increasingly technological society, the ability of workers to solve complex scientific problems and to use advanced mathematical skills are crucial components of the Nation's ability to compete in the global marketplace. Early success in mathematics and science is important, both because a firm foundation in basic principles is necessary before more complex material can be mastered and because early success can keep young people interested in these fields. The National Assessment of Educational Progress (NAEP) has assessed the knowledge of 9-, 13-, and 17-year-olds in reading, mathematics, science, and other fields for more than 20 years. Differences in the performance of both younger and older female and male students can be examined over time with these data.

- **Boys and girls have similar mathematics and science proficiency scores at age 9.**

As the mathematics proficiency of both female and male 9-year-olds has increased since the early 1970s, the gap in scores that previously favored girls has disappeared. Between 1973 and 1994, the average mathematics proficiency of both 9-year-old girls and boys increased (10 and 14 points, respectively). In 1994, there was no measurable difference in the mathematics proficiency of female and male 9-year-olds.[4]

Science scores of 9-year-olds declined in the 1970s, but have since improved. In 1994, 9-year-old girls scored 7 points higher on the NAEP science assessment than did their counterparts in 1970. Science proficiency was similar for 9-year-old boys and girls in 1994.[5]

- **A gender gap in science proficiency scores begins to appear at age 13.**

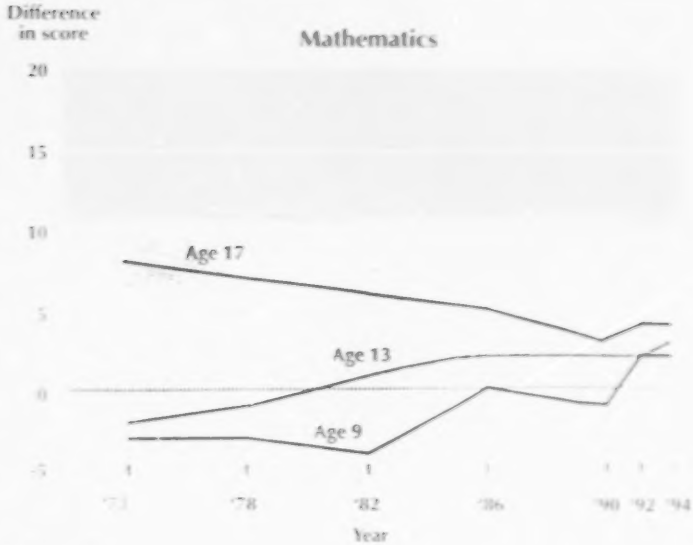
Average scale scores on the NAEP mathematics assessment increased between 1973 and 1994 for both girls and boys at age 13 (6 and 11 points, respectively). In 1994, there was no measurable difference in the mathematics proficiency of male and female 13-year-olds.

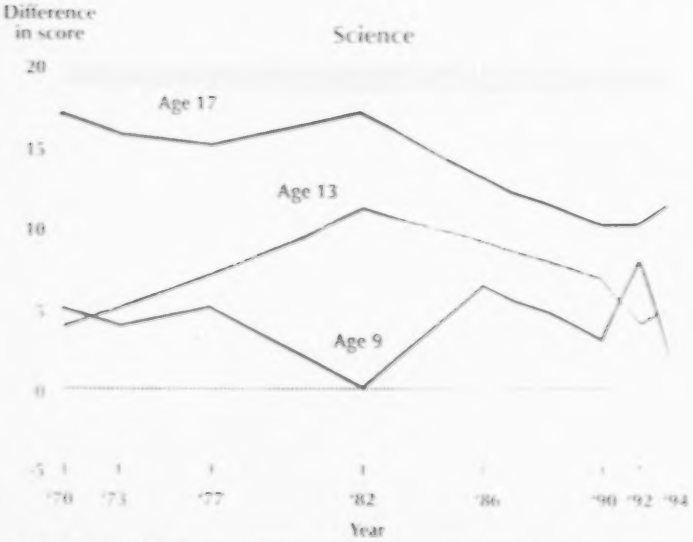
Since 1970, 13-year-old boys have outperformed girls in science. In 1994, 13-year-old boys scored 5 scale points higher than girls of the same age. For both male and female 13-year-olds, science scores in 1994 were not different from scores in 1970 within each gender group.[6]

- **In general, the international pattern of gender differences in mathematics scores is less pronounced than that in science for many countries. Eighth-grade boys in most countries have higher average science scores than girls.**

The Third International Mathematics and Science Study (TIMSS) is one of the largest international comparative studies conducted by the International Association for the Evaluation of Educational Achievement (IEA). More than half a million students at five grade levels in 15,000 schools and from more than 40 countries around the world participated in this study. International comparisons from this study allow us to see whether or not differences observed across groups in the United States are unique or if they mirror differences observed in other countries. According to TIMSS, among most participating countries, the pattern of differences indicates that girls and boys either had similar average mathematics achievement scores, as was the case for the United States.[7] In science, for many countries, eighth-grade boys had higher average science achievement scores than did girls.

Trends in differences in average scale scores (scores of male minus female), by age: Selected years 1970–94





SOURCE: NCES, *NAEP 1994 Trends in Academic Progress*, 1996.

In both mathematics and science, 17-year-old females have consistently scored lower, on average, than 17-year-old males. In 1994, females scored 5 scale points lower than males on the NAEP mathematics assessment (roughly equivalent to almost one-half year of schooling), and 11 scale points lower on the science assessment (about 1 year's worth of science).

Average mathematics proficiency scores among 17-year-old female students declined between 1973 and 1982, increased since 1982, and in 1994, the average mathematics proficiency scores of 17-year-old females were similar to their female counterparts in 1973. In 1994, the gap was not statistically different from that in 1973.

- **The gender gap in the science proficiencies of male and female 17-year-olds has narrowed over time.**

Among 17-year-old females, the 1994 average science proficiency score was lower than the 1969 score, despite improvement in average proficiency scores between 1986 and 1994. At age 17, the gap between the average science proficiency scores of males and females was generally smaller between 1986 and 1994 when compared to the gap observed before 1986. The reduction in the gap resulted from gains for female students in 1986 (7 points) and in 1990 (3 points) compared to male students (3 points in 1986 and 1 point in 1990).[8]

Recent research analyzing patterns across three nationally representative longitudinal data sets finds that young women fall behind in science before they fall behind in mathematics: Women score lower on standardized science exams by 7th grade and on mathematics exams by 10th grade.[9]

- **Men score higher than women on the SAT mathematics and science Achievement Tests, as well as on the mathematics and science Advanced Placement (AP) examinations.**

The Achievement Tests, which students can elect to take when they register for the Scholastic Assessment Test (SAT), measure knowledge in specific subject areas. The tests are designed to be independent of particular textbooks or instructional methods. Among students taking the 1991 Achievement Tests in mathematics and science, scores varied substantially by gender. On a scale of 200–800, males consistently scored higher than females in the subject areas, with differences ranging from 33 points on the biology test to 59 points on the physics test.[10]

AP examinations are administered by the College Board for high school students who are enrolled in AP courses. Approximately 15 percent of college-bound seniors elect to take at least one AP examination.[11] These examinations are graded on a scale from 1 (no recommendation for college credit) to 5 (extremely well qualified in the subject area). Test-takers scoring 3 or above on an AP examination may receive college credit or appropriate placement in that subject area. Males were more likely than females to take AP examinations in calculus, computer science, and specific science subjects, and were also more likely to score 3 or higher in these areas.[12]

Number of AP examinations taken and the number of examinations with scores of 3 or higher (per 1,000 11th- and 12th-grade students), by sex: 1995

	Male	Female
Examinations taken		
Calculus	18	16
Science	19	17
Scored 3 or higher		
Calculus	12	9
Science	13	9

SOURCE: The College Board, Advanced Placement Program, *National Summary Reports*, various years (Copyright © 1996 by the College Entrance Examination Board. All rights reserved.). U.S. Department of Commerce, Bureau of the Census, October Current Population Surveys.

Attitudes Toward Mathematics and Science

Students' perceptions about the value of learning mathematics and science may be considered as both inputs to and outcomes of the educational process, since their attitudes toward these subjects can be related to educational achievement in ways that reinforce higher or lower performance.[13] In other words, students who do well in mathematics and science generally have more positive attitudes toward those subjects, and those who have more positive attitudes tend to be more likely to take courses in those subjects and to perform better.

In the United States, research findings are mixed concerning the grade in which boys' and girls' attitudes about mathematics and science diverge. Analyzing several nationally representative longitudinal studies, one researcher found few differences between girls and boys in their attitudes about science in the early secondary school years.[14] For example, in seventh and eighth grades, girls were no more anxious than boys about mathematics or science and were just as likely to believe that mathematics knowledge is necessary for obtaining a good job. These findings contrast with those who have found that girls' attitudes are more negative even in the early years.[15]

- **Data from the late 1980s and early 1990s indicate that 7th- and 10th-grade boys and girls are equally likely to say that they enjoy mathematics and science. Among 12th-graders, however, a gender gap emerges in science.**

Data from the Longitudinal Study of American Youth indicate that 7th- and 10th-grade boys and girls have a similar liking for mathematics and science. Among both 7th-graders in 1987–88 and 10th-graders in 1990–91, boys and girls had similar responses to questions regarding how much they liked mathematics and

science in general and how much they liked the subject matter of their mathematics and science classes in particular. Among 12th-grade students in 1989-90, males were about as likely as females to agree or strongly agree that they enjoyed mathematics (57 and 52 percent, respectively), while males were more likely to agree or strongly agree that they enjoyed science (60 and 48 percent, respectively).[16]

- **While attitudes toward mathematics and science were similar between boys and girls in the United States in eighth grade, boys typically had more positive attitudes about mathematics than did girls in France, Germany, and Japan.**

Gender differences in eighth-grade students' perceptions toward mathematics and science mirrored achievement differences in TIMSS.[17] In general, eighth-grade students had positive attitudes toward mathematics, and those with more positive attitudes had higher average mathematics achievement. In many countries, including the United States, girls and boys reported similar overall attitudes about mathematics. A gender gap in attitudes about mathematics appeared in several large industrialized countries, however. For example, boys' attitudes were more positive than those of girls in France, Germany, and Japan.

Data from TIMSS also indicate that across countries, eighth-grade girls generally had lower perceptions than boys about how well they usually did in mathematics. Boys were more likely than girls to report that they usually did well in mathematics in England, France, Germany, and Japan. Self-perceptions about mathematics performance were similar between eighth-grade boys and girls in the United States, however.[18]

In TIMSS, eighth-grade students were also asked how much they liked or disliked science. In England and Japan, boys reported liking science more than girls did. The percentages of female and

male eighth-graders who reported that they liked science were similar in the United States and Canada.[19]

While positive attitudes toward mathematics and science can be related to better performance and higher educational achievement, participation in activities related to these fields may also help to keep students interested in the fields of mathematics and science. There is some evidence that boys are more likely than girls to participate in mathematics- and science-related activities. For example, one researcher who used longitudinal data sets to follow students over time found that in the middle school years boys were more likely than girls to have talked to a scientist or attended a computer club, or to have used a computer for a significant amount of time during the week, or to have a computer or microscope at home. By 10th grade, boys were more likely than girls to have conducted their own science experiments, to have a computer or calculator at home, or to have used a computer more often during the week. In contrast, girls were spending more time on mathematics or science homework. Nonetheless, in the years after high school, girls were more likely than boys to have used a pocket calculator and to have used a computer terminal. This research shows that girls start out with a deficit in activities related to mathematics and science and gain some ground over time.[20]

Career Expectations in Science, Mathematics, and Engineering

Students' aspirations toward careers in mathematics and science are likely to influence both their course taking in those areas and the level of effort put forth in their coursework.

- **A gap in the career aspirations of boys and girls in science or engineering exists as early as eighth grade.**

As early as eighth grade, students have some idea about the type of work that they would like to do as adults. Among the eighth-grade class of 1988, boys were more than twice as likely as girls to aspire to be scientists or engineers (9 and 3 percent, respectively), although girls were more likely than boys to aspire to professional, business, or managerial occupations (38 and 20 percent, respectively).[21]

- **While male and female high school seniors are equally likely to expect a career in science or mathematics, male seniors are much more likely than their female counterparts to expect a career in engineering.**

Overall, few high school seniors expect to have a career in science/mathematics or engineering: About 5 percent plan to have a career in engineering, while about 1 percent plan a career in science or mathematics. Males and females are about equally likely to expect to pursue a career in science or mathematics; however, males are considerably more likely (9 percent) than their female classmates (2 percent) to anticipate a career in engineering.[22]

Mathematics and Science Course-Taking Patterns in High School

According to many researchers, the pool of talent from which the Nation's future scientists and engineers come is largely formed in high school. In order to adequately prepare themselves for careers in mathematics and science, students must take and excel in advanced mathematics and science courses in high school.

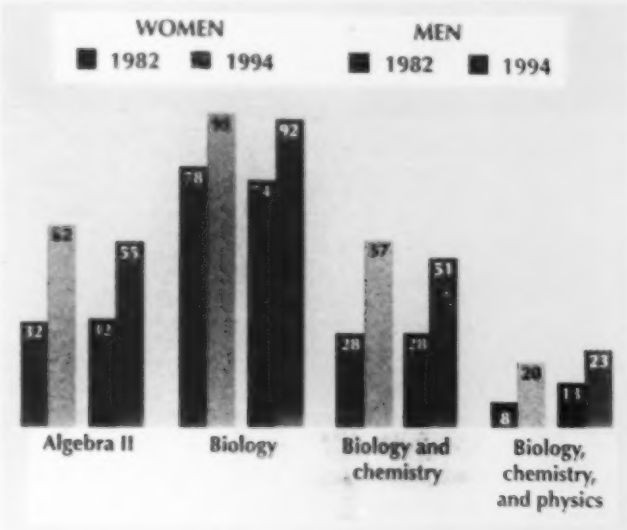
- **In general, female students are just as likely as male students to take advanced mathematics and science courses in high school; physics is the exception.**

For many mathematics and science subjects, gender parity had been attained by 1982, and between 1982 and 1994, the percentage of both female and male graduates who took advanced mathematics and science courses in high school increased. In the class of 1994, females were more likely than males to take algebra II in high school, and were just as likely to take calculus. With respect to science, females were just as likely as males to take biology, and were more likely to take chemistry. Females have continued, however, to be less likely than males to take physics.[23]

Other research has shown that women taking mathematics courses are taught similar amounts of mathematics and receive grades that are similar to (or better than) those of their male counterparts.[24]

- **Female seniors were more likely than male seniors to say that they did not take additional mathematics because of poor performance in the subject matter.**

Percentage of high school graduates who took selected mathematics and science courses, by sex: 1982 and 1994



SOURCE: NCES, *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates*, 1996.

Almost one-third of the 1989–90 seniors who did not take mathematics or science in their last year of high school reported being advised by others that they did not need additional coursework in these subjects. Females were more likely than males to say that they had been advised against taking these courses (32 and 26 percent, respectively). Dislike of the subject matter was given as the reason for not enrolling by about 35 percent of the seniors who were not taking mathematics, while about 30 percent cited this reason for not enrolling in science. Female seniors were more likely than their male peers to say they did not take mathematics and science courses because they disliked the subject matter (35 and 22 percent, respectively). Males were slightly more likely than females to report that they did not need advanced science or mathematics courses for what they planned to do in the future.

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While similar proportions of males and females said they did not enroll in science because they did not do well in these courses, females were more likely than their male peers to say poor performance in the subject kept them from taking additional mathematics classes.[25]

Women in Mathematics and Science at the Postsecondary Level

Although male students' achievement in mathematics and science is higher than that of female students at the end of high school, similar high school course-taking patterns in these fields may indicate similar preparation for study in mathematics and science in college. The intended majors of first-time college freshmen provide an indication of the relative interest men and women have in mathematics and science at the postsecondary level.

- **Male first-time college freshmen were more likely to choose engineering as an intended field of study, while female first-time freshmen were more likely to choose professional fields, education, and social sciences.**

A 1996 study of college freshmen by the Higher Education Research Institute shows that men and women differ greatly in their intended fields of study. Of first-time freshmen in 1996, 20 percent of men and 4 percent of women planned to major in computer sciences or engineering, while similar percentages of male and female freshmen planned to major in biology or physical sciences. Female freshmen were more likely to plan to major in professional fields, education, social sciences, or humanities than their male counterparts.

Percentage distribution of probable fields of study among first-time college freshmen, by sex: Fall 1996

Probable major field of study	Men	Women
Arts and humanities	9.4	10.5
Biology	6.5	7.4
Business	18.1	13.8
Education	6.3	14.2
Engineering	15.2	2.6
Physical sciences[1]	2.7	2.0
Professional[2]	9.8	20.2
Social sciences	6.1	11.7
Technical	3.7	1.4
Computer sciences	4.3	1.2
Other	10.5	6.5
Undecided	7.4	8.8

[1]Includes fields such as astronomy, chemistry, earth science, mathematics, and physics.
[2]Includes fields such as architecture and health technologies.

SOURCE: Higher Education Research Institute, Graduate School of Education and Information Studies, *The American Freshman: National Norms for Fall 1996*, University of California, Los Angeles, 1996.

The differences in the intended majors of male and female first-time freshmen directly relate to the differences in the fields in which men and women earn their degrees. The differences in degrees conferred to women and men are best illustrated by a female field concentration ratio. This ratio is calculated as the percentage of females earning degrees who majored in a specific field divided by the percentage of males earning degrees who majored in the same field. A ratio above 1.0 indicates that females are more likely than males to major in a field, and a ratio below 1.0 indicates the opposite is true.

- **At the postsecondary level, women are less likely than men to earn a degree in mathematics, physical sciences, and computer sciences and engineering. The exception is in life sciences degrees.**

While earning a bachelor's degree is associated with long-term economic advantages,[26] the fields in which college students choose to earn a degree also affect the career potential after graduation. More than 20 years ago, women were less likely to earn a bachelor's degree in life sciences, mathematics, physical sciences, computer sciences and engineering fields than their male counterparts. Instead, women were about four times as likely as men to earn a degree in education and the health professions. This tendency of women and men to choose different fields of study has shifted somewhat over the past 20 years. For example, differences

Female field concentration ratio of bachelor's degrees conferred: Academic years ending 1971, 1982, and 1994

Field of study	1971	1982	1994
Humanities	1.84	1.41	1.32
Social sciences and history	0.76	0.80	0.72
Psychology	1.04	1.99	2.27
Life sciences	**0.54**	**0.82**	**0.88**
Physical sciences*	**0.80**	**0.74**	**0.42**
Mathematics	**0.21**	**0.34**	**0.72**
Computer sciences	**0.21**	**0.53**	**0.33**
Engineering	**0.01**	**0.13**	**0.15**
Education	3.82	3.10	2.84
Business management	0.13	0.64	0.76
Health professions	4.39	5.23	3.93

*Includes fields such as physics, chemistry, astronomy, and geology.

SOURCE: NCES, *Digest of Education Statistics*, various years (based on IPEDS/HEGIS "Completion" survey).

in the proportion of women and men earning a degree in life sciences and mathematics have narrowed substantially over time. While the gap between women and men who earned a degree in computer sciences and engineering narrowed, the gap between women and men who earned a degree in physical sciences, such as physics and chemistry, increased. In 1994, women were more likely to earn a bachelor's degree in psychology, education, health sciences, and the humanities.

- **Even though men were more likely than women to earn master's degrees in science, gaps in the proportion of life sciences, physical sciences, and computer sciences and engineering degrees earned by women and men decreased somewhat in the past 20 years.**

At the master's degree level, in the past 20 years, the differences between the proportions of women and men who earned master's degrees in life sciences, physical sciences, and computer sciences and engineering have narrowed. Between 1971 and 1986, the difference in the proportions of men and women who earned master's degrees in computer sciences and engineering narrowed each year; since 1986, this difference has remained stable with men being five times more likely than women to earn a master's degree in computer sciences and engineering.[27] However, the gap between the proportions of mathematics graduate degrees conferred to women and men has increased somewhat in the past 20 years. In 1994, men were twice as likely to earn a master's degree in mathematics as women.

At the doctor's degree level, women were more likely than men to earn a degree in life sciences; however, they were less likely than men to earn a degree in physical sciences, mathematics, and computer sciences and engineering, although the differences in the proportions of women and men who earned degrees in most of these fields have narrowed over time.

Female field concentration ratio of graduate degrees conferred: Academic years ending 1971, 1982, and 1994

Field of study	1971	1982	1994
Master's degrees			
Life sciences	0.76	0.69	0.92
Physical sciences*	0.23	0.27	0.35
Mathematics	0.56	0.43	0.51
Computer sciences and engineering	0.03	0.14	0.19
Computer sciences	0.17	0.35	0.29
Engineering	0.02	0.10	0.15
Doctor's degrees			
Life sciences	1.17	0.87	1.09
Physical sciences*	0.36	0.34	0.44
Mathematics	0.50	0.33	0.45
Computer sciences and engineering	0.04	0.13	0.21
Computer sciences	0.14	0.19	0.29
Engineering	0.04	0.12	0.20

*Includes fields such as physics, chemistry, astronomy, and geology.

SOURCE: NCES, *Digest of Education Statistics*, various years (based on IPEDS/HEGIS "Completion" survey).

Gender Differences in Employment and Earnings in Mathematics and Sciences

Although female college graduates shared in the earnings growth of all college graduates in the 1980s, they earned less on average than male college graduates. Some of the differences in salary may be related to the occupations women and men entered. Among employed recent science and engineering bachelor's degree recipients, women were less likely than men to be employed in science and engineering occupations.[28] For example, 18 percent of employed recent female science and engineering graduates were employed in science and engineering occupations in 1993, compared to 35 percent of their male counterparts.

- **The salary differential between women and men in comparable scientific jobs is still evident.**

There remains an earnings gap between men and women in comparable scientific positions. Among more experienced bachelor's and master's scientists and engineers, the gap between men's and women's salaries is larger than for recent graduates.[24] Some of the difference in salary is due to differences in the field in which they are employed. Salaries are highest in mathematics/computer science and engineering, fields in which women are not highly represented. Such factors as the number of years in the labor force, primary work activity, supervisory status, and number of people supervised also influence salaries and may account for some of the gap.

- **Among recent college graduates who majored in the natural sciences, women earned less than men did. There was no measurable difference between the starting salaries of men and women who majored in computer sciences and engineering, however.**

College graduates who majored in computer sciences and engineering had much higher starting salaries than did all college graduates. On the other hand, graduates who majored in the natural sciences or mathematics earned less than the typical graduate did. Although median starting salaries for 1993 female recent graduates were substantially lower than those of male graduates, there was no measurable difference between the starting salaries of men and women who majored in computer science and engineering. Women who majored in the natural sciences earned 15 percent less than men who majored in the same field, however.

Annual median starting salaries (in 1996 constant dollars) of 1993 college graduates, by major field of study

Major field of study	All graduates	Men	Women	Women's salary as a percentage of men's
Total	**$23,600**	**$26,122**	**$21,990**	***84.2**
Natural sciences/ mathematics	21,833	24,226	20,508	*84.7
Computer sciences and engineering	32,046	32,385	30,155	93.1

*Male salaries significantly greater than female salaries ($p<0.05$).

SOURCE: NCES, Recent College Graduates Surveys (1977-90) and 1993 Baccalaureate and Beyond Longitudinal Study, First Follow-up (B&B:93/94).

SUMMARY

Women have made important advances in education over the last few decades, closing the gender gap in the level of educational attainment among younger women that existed 20 years ago. In fact, for several years, women have been awarded the majority of associate's, bachelor's, and master's degrees. However, a gender gap still exists with respect to mathematics and science, and it widens as students climb the education ladder. Although boys and girls have similar mathematics and science proficiencies at age 9, a gap begins to appear at age 13. At age 17, there is some evidence that the gender gap in mathematics and science has narrowed over time, although a substantial gap remains. Internationally, a gender gap in science is common across countries at grade 8, while it is less evident in mathematics.

Even though girls are less likely than boys to aspire to careers in science or engineering as early as grade eight, boys' and girls' attitudes toward mathematics and science appear to be similar

up to grade 10 (a time when the attitudes of boys and girls have already diverged in other large industrialized countries). Among U.S. 12th-graders, however, a gender gap in attitudes is apparent in science.

The mathematics and science courses that women and men take in high school are similar, with the exceptions that women remain less likely than men to study physics but are more likely to take chemistry. Among students who do not take mathematics or science in their senior year, women are more likely than men to say that they did so either because others advised them that they did not need those courses or because they disliked the subject matter.

While women are just as likely as men to go to college immediately after high school, from the start they are less interested in majoring in mathematics and science. Although women tend to major in different subjects than men in college, some of these differences have narrowed over time. The mathematics and science fields continue to be areas where the gender gap remains large. Women are far less likely than men to earn bachelor's degrees in computer science, engineering, physical sciences, or mathematics.

Even though women make up about half of the labor market, they are both underrepresented in jobs in scientific fields and are paid less than men. Some of these differences can be explained by differences in the field chosen, level of experience, and level of education. Overall, there are still substantial differences between women and men in mathematics and science fields, and these differences appear as early as middle school.

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For more information, see the following NCES publications:

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